ERA HELICOPTERS, INC.

PROCESS SPECIFICATION

ERA HELICOPTERS, INC.

GULF COAST DIVISION
LAKE CHARLES, LOUISIANA

PROCESS SPECIFICATION NO. 4001

GAS TUNGSTEN ARC WELDING

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LOG OF REVISIONS

REVISION	DATE	PAGES AFFECTED	REVISION DESCRIPTION	APPROVED DATE
IR	Jim Dugelby 02/03/87	ALL	Initial Release	Jim Dugelby 02/03/87
A	D. Marwill 07/15/02	ALL	Completely revised to add more details for welding of various steels and titanium.	P. Schwartz D. Murphy 07/15/02
B	D. Marwill 03/23/04	ii, 2, 18	Add AWS D17.1:2001 Specification for Fusion Welding for Aerospace Applications	P. Schwartz on 04/29/04 D. Marwill on 4/16/04
C	D Marwill 03/08/05	ii, 6, & 8	Incorporated EO# B-1. Added Hastelloy X wire and filler metal to tables 4-2 and 4-5. Reason: to provide more crack-resistant welds on high temperature parts.	P. Schwartz on 04/06/05

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1 SCOPE

This specification establishes the requirements and procedures applicable to gas tungsten arc welding (GTAW) of aluminum alloys, low alloy steels, stainless steels, and nickel based alloys for aircraft parts applications. This process specification shall be used when specified on Era drawings or for repairs to existing parts as specified on repair orders.

2 APPLICABLE SPECIFICATIONS AND DEFINITIONS

2.1 Specifications

2.1.1	MIL-T-5021D	Test, Aircraft Welding Operators' Certification.
2.1.2	MIL-W-8611	Welding, Metal Arc and Gas, Steels, and Corrosion and Heat Resistant Alloys
2.1.3	MIL-W-8604	Welding of Aluminum Alloys
2.1.4	MIL-S-5002	Surface Treatments and Inorganic Coatings for Metal Surfaces
2.1.5	AWS A2.0-68	Standard Welding Symbols - American Welding Society
2.1.6	QQ-R-566	Rods, Welding, Aluminum and Aluminum Alloys
2.1.7	MIL-E-19933	Electrodes and Rods - Welding, Bare Chromium and Chromium - Nickel Steels
2.1.8	Boiler and Pressure Vessel Code, Sec. IX-American Society of Mechanical Engineers, 1974	
2.1.9	MIL-STD-1595	Aerospace Welder Performance Qualification
2.1.10	AWS A5.10	Specification For Bare Aluminum Alloy Welding Electrodes And Rods
2.1.11	AWS A5.12	Specification for Tungsten Arc Welding Electrodes

2.1.12	AWS A5.14	Specification for Nickel and Nickel Alloy Welding Electrodes and Rods
2.1.13	MIL-F-6939	Flux, Aluminum and Aluminum Alloy, Gas Welding
2.1.14	MIL-F-7516	Flux, Welding, Corrosion and Heat Resistant Alloy
2.1.15	MIL-R-5632	Rods & Wire, Steel, Welding
2.1.16	AWS-D17.1:2001	Specification for fusion welding for Aerospace Applications

2.2 Definitions

2.2.1	Defect -	One or more discontinuities which individually or in aggregate fail to meet the minimum acceptance standards.
2.2.2	Discontinuity -	An interruption of the normal structure of a weld joint
2.2.3	Incomplete Fusion -	Failure to fuse together adjacent base metal and weld metal, a discontinuity
2.2.4	Incomplete Penetration -	An area or areas at the root of the weld which did not melt and have not fused together, a discontinuity
2.2.5	Porosity -	Gas holes or voids in the weld, a discontinuity
2.2.6	Inclusions -	Metal, metallic oxides or other solid compounds trapped in the weld, a discontinuity
2.2.7	Overlap -	Weld metal which overlaps the base metal but which is not fused to it, creating a discontinuity
2.2.8	Undercut -	A groove melted into the metal adjacent to the edge of the weld which is not filled with weld metal, a discontinuity

2.2.9	Weld Metal Thinning -	A reduction in thickness of the base metal on the side opposite to that from which the weld was deposited
2.2.10	Excessive Penetration -	Weld metal excessively protruding on the opposite side from which the weld was deposited
2.2.11	Reactive Metals -	Reactive metals are Titanium and Columbium/Niobium and their alloys

3 WELD SPECIFICATION

3.1 Drawing Callout

The type and method of welding shall be as specified on applicable drawings or repair orders. The drawing or repair order shall be specific in defining the process specification number and class of inspection for all welding of aircraft parts. A typical sample note may be as follows:

1. Weld in accordance with Era Process Specification No. 4001, Class _____.

See Paragraph 3.2 for weld classifications. If a weld class is not specified, it is assumed to be a class "C".

3.2 Weld Classifications

Welds shall be classified according to the degree of inspection required to determine the quality of process. The following classes shall be used:

Weld Class	Weld Quality	Non-Destructive Testing Inspection Requirements	Testing/Inspection Specification
A	High	(a) Visual Examination	Unaided eye to 10X magnification
		(b) Magnetic Particle Inspection or Dye Penetrant Inspection depending upon material type	MIL-STD-1949 MIL-STD-6866
		(c) Radiographic Examination	MIL-STD-453 Sensitivity level 2-2T
B	Medium	(a) Visual Examination	Unaided eye to 10X magnification
		(c) Radiographic Examination	MIL-STD-453 Sensitivity level 2-2T
C	Normal	(a) Visual Examination only	Unaided eye to 10X magnification

NOTE: Magnetic Particle or Dye Penetrant Inspection may be performed in any class of weld as required by the Engineering drawing or by other Engineering authority.

4 MATERIALS

4.1 Specifications

The materials used in this welding specification shall be closely controlled to ensure high quality in the finished product. Tables 4-1, 4-2 and 4-3 provide the specification standard and/or purchase source for the electrodes, welding rod, and cleaning supplies, respectively, required by this specification.

4.2 Tungsten Electrodes

4.2.1 Tungsten electrodes for use in welding aluminum alloys shall be pure tungsten or 2% Thoriated tungsten (reference Table 4-1).

4.2.2 Tungsten electrodes for use in welding steels, reactive metals, and nickel base alloys shall be 2% Thoriated and 2% Ceriated tungsten (reference Table 4-1).

Product Description	Specification	Supplier
Pure Tungsten Electrode	AWS A5.12 Class EWP	
2% Thoriated Tungsten Electrode	AWS A5.12 Class EWTh[2]	
2% Ceriated Tungsten Electrode	AWS A5.12 Class EWC	

Table 4-1
ELECTRODES

Product Description	Specification	Supplier
4043 Al Welding Rod	AMS 4190	
2319 Al Welding Rod	AMS 4191	
347 SS Welding Rod	AMS 5680	
410 SS Welding Rod	AMS 5776	
PH15-7Mo SS Welding Rod	AMS 5812	
17-7PH SS Welding Rod	AMS 5824	
17-4PH SS Welding Rod	AMS 5825	
15-5PH SS Welding Rod	AMS 5826	
718 Inconel Welding Rod	AMS 5832	
625 Inconel Welding Rod	AMS 5837	
4130 Low Alloy Steel Welding Rod	AMS 6457	
Type 502 Low Alloy Steel Welding Rod	AMS 6466	
5356 Al Welding Rod	ANSI A5.10	
308 SS Welding Rod	MIL-E-19933	
308L SS Welding Rod	MIL-E-19933	
A286 Welding Wire	AMS 5805	
Ph13-8Mo Welding Wire	AMS 5840	
Hastelloy W Welding Wire	AMS 5786	
Hastelloy X Welding Wire	AMS 5798	
Inconel 82 Welding Wire	AWS A5.14, Class ERNICr-3	
Ti-CP Welding Rod	AMS 4951	
Ti-6A1-4V Welding Rod	AMS 4954	
Anti-Borax #8 Welding Flux	MIL-F-6939	

Table 4-2
WELDING ROD (wire)

Product Description	Specification	Supplier
Turco W.O. No. 1	Commercial	Henkel Surface Technology 32100 Stepenson Madison Heights, MI 48071
Turco W.O. No. 2	Commercial	Henkel Surface Technology 32100 Stepenson Madison Heights, MI 48071
Turco 4140 (NITRADD)	Commercial	Henkel Surface Technology 32100 Stepenson Madison Heights, MI 48071
MEK	Commercial	
Abrasive Pads, Nylon	Scotchbrite Type A, very fine	
Paper, Sand, Aluminum Oxide	Commercial	
Nitric Acid (70%)	Commercial	
Phosphoric Acid (85%)	Commercial	
Gloves, Cotton	White Lisle, Light Weight	Magic Glove Co. Chicago, IL

Table 4-3
CLEANING SUPPLIES

4.3 Electrode Diameter

Electrode diameters shall be chosen to be compatible with the welding current used. Use Table 4-4 as a guide to choosing the appropriate electrode diameter.

Electrode Diameter (Inch)	Electrical Current (Amps)	
	Alloys Other Than Aluminum	Aluminum
.040	0 - 40	0 - 30
1/16	30 - 100	20 - 80
3/32	80 - 160	60 - 120
1/8	120 - 300	100 - 250

Table 4-4
RECOMMENDED ELECTRODE DIAMETERS

4.4 Filler Metals

Filler metals used for GTAW shall be chosen from Table 4-5 for the corresponding base metal or base metal combinations listed. Any filler metal variations to corresponding base metals or filler metal selections for base metals not listed shall require prior approval from engineering.

	Base Metal Alloy	Filler Metal
Aluminum	1100, 3003, 6061 Above alloys welded to themselves or in any combination	4043
	2219	2319
	5052 or 6061 to be Anodized (Appearance Item)	5356
Stainless Steel	201, 202, 301, 302, 304*, 305, and 308 * Heavy welded sections ¼ inch or thicker may require post-welded annealing for maximum corrosion resistance.	308
	304L and 308L	308L
	316, 316L, 321, 347	347
	321 and Hastelloy X	AMS 5798
	15-5PH, 17-4PH	W15-5PH or W17-4PH
	PH15-7Mo	WPH15-7Mo
	17-7PH	W17-7PH
	A286	A286 per AMS 5805 or equivalent (Vacuum induction Melted)
	PH13-8 Mo	WPH 13-8Mo
Dissimilar Metals	Inconel 625, 718; 3XX Stainless Steel Alloys welded in any combination	Inco 625 or Inco 82 or Hastelloy W
	15-5PH or 17-4PH to 3XX Stainless Steel	15-5PH or 17-4PH or 347
	PH13-8Mo to 15-5PH 17-4PH or 3XX SS	WPH13-8Mo
Nickel Base Alloys	Inconel 625	Inco 625
	Inconel 718	Inco 718
Titanium	Commercially Pure (C.P.)	C.P. - Tiper AMS 4951
	6Al-4V or 3Al-2.5V (also use for welding to C.P.)	6-4 per AMS 4954 use AMS 4956 for Class A welds

(Table 4-5 continued on next page)

	Base Metal Alloy		Filler Metal
Low Alloy Steel	**Base Metal**	**Max Heat Treat after Welding**	**Filler Metal**
	4130	150-180 KSI	4130
	4135, 4140, 4330, 4340	170-200 KSI	Type 502

TABLE 4-5
WELDING FILLER METAL

4.5 Shielding

4.5.1 Inert Gases - Only Argon, Helium, or mixtures of the two gases shall be used for GTAW under normal shop conditions.

4.5.2 Torch gas - All GTAW torches shall provide sufficient inert gas (typically 5-50 cfh) to effectively shield the weld from discoloration, and/or oxidation. Cups, collets, or gas lenses may be chosen as desired providing the above conditions are maintained.

4.5.3 Back-up Shielding - For partial penetration welds in heavy sections, where oxidation is not a problem, no back-up shielding is required. Back-up shielding is optional for aluminum weldments. All other welds shall have back-up shielding provided prior to welding. Back-up shielding may be inert gas, or for aluminum alloys, flux may be used.

4.5.3.1 When gas is chosen for back-up shielding, the weld area shall be purged with a volume of gas equal to about 8 times the volume of air being displaced before initiating the welding arc. Use Table 4-6 as a guide to purge times and flow rates for tubular parts. Always using purge dams to purge the smallest area practicable.

Part Diameter (inches)	Purge Time Per Foot of Length			
	Gas Flow			
	10 CFH	20 CFH	30 CFH	40 CFH
1	15 Sec.			
1.50	30 Sec.	15 Sec.	12 Sec.	10 Sec.
2	1 Min.	30 Sec.	24 Sec.	15 Sec.
2.50	1 1/2 Min.	45 Sec.	30 Sec.	25 Sec.
3	2 1/4 Min.	1 1/4 Min.	45 Sec.	35 Sec.
3.50	3 1/4 Min.	1 1/2 Min.	1 Min.	45 Sec.
4	4 1/4 Min.	2 Min.	1 1/2 Min.	1 Min.
4.50	5 1/4 Min.	2 1/2 Min.	1 3/4 Min.	1 1/4 Min.
5.50	8 Min.	4 Min.	2 3/4 Min.	2 Min.
6	12 Min.	6 Min.	4 Min.	3 Min.

Table 4-6
PURGE TIME RECOMMENDATION PER FOOT
OF LENGTH FOR TUBULAR PART

4.5.3.2 When flux is chosen for back-up shielding for aluminum alloys, use Anti-Borax #8 flux.

- Flux shall be applied per paragraph 8.5.
- Flux shall be removed within 24 hours of welding, per paragraph 8.6.

5 ACCEPTABLE PRACTICES

5.1 Joint Design

Joint design shall be as specified on the Engineering drawing, and shall not violate the restrictions of paragraphs 5.1.3, 5.1.4, and 5.4.2. The following joint designs are specifically recommended for use.

5.1.1 Butt Weld - Butt welds may be prepared square butt, singe bevel or double bevel dependent upon join thickness. All butt welds shall be full penetration welds (see Figure 5-1).

5.1.2 Fillet Welds - Fillet welds are normally partial penetration welds, but may be prepared so that full penetration welds are achievable. (See Figure 5-2.)

5.1.3 Flange Welds - Edge and corner flange welds are acceptable for use with no more than 3 members in any one weld. Center flange welds (commonly called melt-down flange welds) are not acceptable for use with aluminum alloys but may be used for steels and nickel base alloys up to .063 inches thick. (See Figure 5-3.)

5.1.4 Corner Welds - Corner welds are acceptable if the configurations in Figure 5-4 are adhered to.

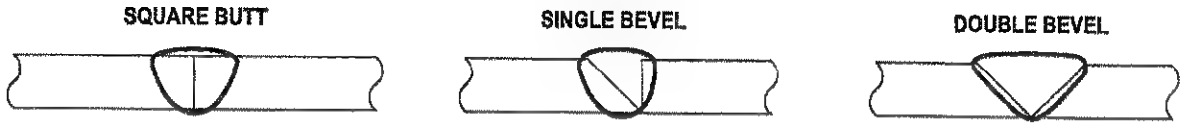

FIGURE 5-1

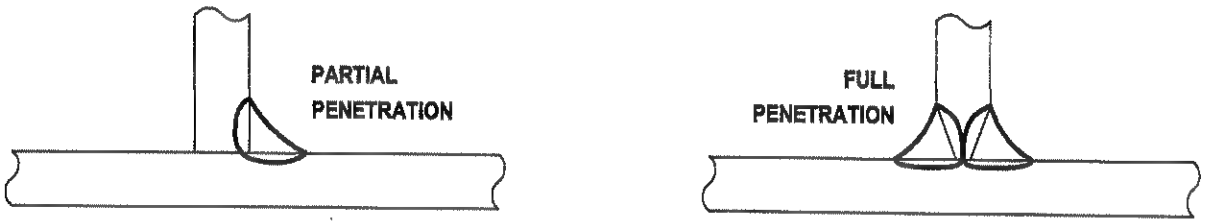

FIGURE 5-2

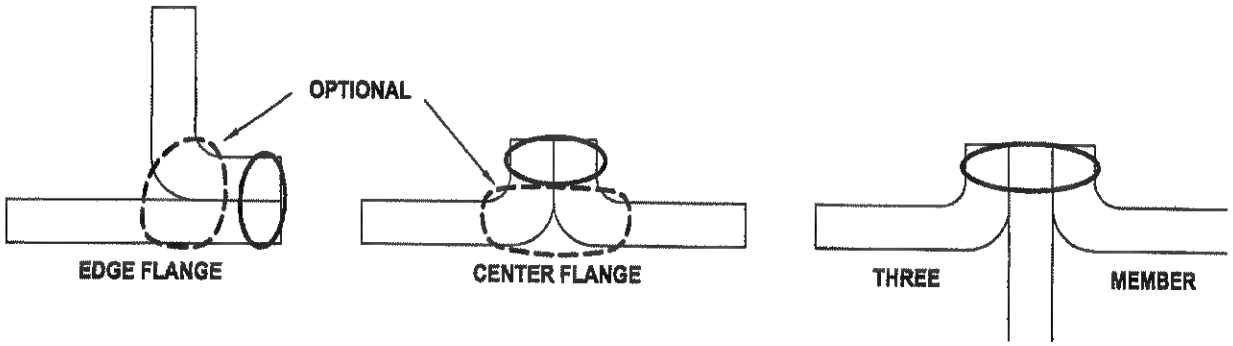

FIGURE 5-3

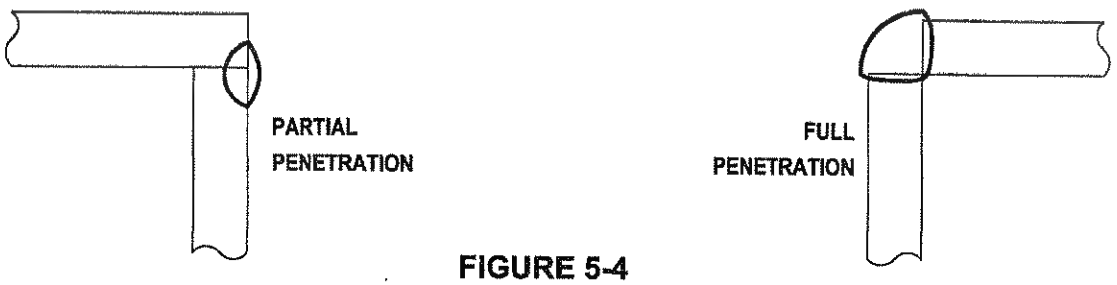

FIGURE 5-4

5.2 Fit Up

5.2.1 Alignment - All welded assemblies shall be aligned and held in position for tacking by one of the following methods.

5.2.1.1 Welding fixtures are a method of holding complex assemblies, or assemblies that require precise alignment. When used, welding fixtures shall permit access for adequate shielding per paragraph 4.5.

5.2.1.2 Small parts or simple assemblies may be held by weights or clamps, providing alignment for tacking is maintained.

5.2.1.3 Assemblies too large for a fixture, or for assemblies that are fabricated in numbers too small for a fixture to be economical to build, may be manually assembled and tacked providing that a suitable tool or gauge is used to verify alignment.

5.2.2 Root Gap & Mismatch - The allowable mismatch and joint gap requirements for butt welds is shown in Table 5-5 and shall be maintained unless otherwise noted on the Engineering drawing.

Base Metal Thickness (in.)	Allowable Root Gap (in.)	Allowable Mismatch (in.)
Up to 0.125	1/2 T or 0.060 whichever is less	0.010 + 0.1 T Max.
0.125 and up	1/2 T or 0.060 whichever is less	0.010 + 0.1 T or 0.040 Max.

NOTE: "T" is the thickness of the thinnest cross section to be welded.

Table 5-5
ALLOWABLE ROOT GAP AND MISMATCH FOR BUTT WELDS

5.3 Tack Welding

5.3.1 All weld assemblies shall be tack welded prior to welding.

5.3.2 Tack welds shall be made using the same welding rod as used for production welding.

5.3.3 Tack welds with visible cracks shall be removed prior to welding.

5.3.4 All tack welds shall be completely consumed by the finished weld.

5.4 Welding Restrictions

5.4.1 Welding over visible oxide films shall not be permitted.

5.4.2 Melt-down flange joint design shall not be used for aluminum.

5.4.3 Parts shall not be sand blasted or dust grit blasted prior to welding.

5.4.4 Stainless steel welds shall not be wire brushed.

5.4.5 Aluminum alloys shall be welded within 24 hours of cleaning, except as noted in paragraph 8.5.2.1.

5.4.6 Flux shall be removed within 24 hours of welding per paragraph 8.7.

5.4.7 Structural welds will not be filed or ground.

5.4.8 If rewelding is necessary, all old weld shall be removed.

5.4.9 Never weld a joint that has previously been brazed.

5.4.10 Parts that depend on structural properties developed by cold working shall not be welded.

5.4.11 Welding scale must be completely and thoroughly removed after completion of welds.

5.5 Tubular Structures

All steel tubular structures will be filled with a preservative such as Lion oil or equivalent and drained after welding is complete. The holes utilized for filling will be plugged after draining.

5.6 Heat Treated Parts

On heat treated members, the proper heat treatable welding rod must be used. After completion of welding, the material must be normalized and reheat-treated unless specified otherwise by engineering instructions.

5.7 Critical Structural Parts

Critical structural parts, such as engine mounts, control surface actuating linkages, and landing gear components will undergo special inspection utilizing magnifying glasses, x-ray, dye penetrant or magnetic particle inspection methods.

5.8 Special Process Inspections

Special process of inspections will be recorded on identification tags or by stamps on the material.

6 CLEANING OF PARTS

6.1 Procedures

All parts or assemblies require cleaning prior to welding to remove oxides and contamination and to avoid excess porosity and inclusions, thus improving weld quality and weldability. Chemical immersion cleaning per paragraph 6.2 is required for all parts or assemblies except as noted below. Mechanical cleaning per paragraph 6.3 must be provided in lieu of chemical cleaning for the following cases:

6.1.1 Wherever entrapment areas exist such as in laps or sockets

6.1.2 Wherever there is dissimilar metal contact that cannot be avoided such as bushings, inserts, or fittings

6.1.3 Whenever the welding together of many details make it impossible to meet the elapsed time requirements established by this specification.

6.2 Immersion Cleaning

6.2.1 Chemically clean parts by immersing in the appropriate solution per the instructions in Table 6-1.

6.2.2 Rinse with hot or cold water immediately after removal from the tank.

6.2.3 Dry parts before removal from the area. A maximum of 190°F air temperature is permitted. Do not permit dust or dirt to blow on parts.

6.2.4 Protect parts from contamination prior to welding by any suitable means such as wrapping, bagging, or boxing.

Material	Applicable Alloys	Cleaning Mixture by Volume	Immersion Time (min.)	Solution Temp. (°F)
Aluminum	1100 series, 3003, 5052, 6061,	**Normal Cleaning:** 1 part Turco W.O. #1 3 to 4 parts water	3 - 10	60 - 80
Carbon Steel	4130, 4135, 4140, 4330, 4340	**Heavy Rust Corrosion and/or Oxides:** 1 part Turco W.O. #2 3 to 4 parts water OR 1 part Turco W.O. #2 10 to 15 parts water	3 - 10 OR 3 - 10	60 - 80 OR 120 - 140
CRES Steel	301, 302, 304, 304L, 305, 316, 316L, 321, 347	14 parts Turco 4104 34 parts nitric acid (70%) 52 parts water	15-20	70 - 85
Inconel	600, 625, 718		15-25	70 - 85
CRES Steel	308 & 308L	7 parts Turco 4104 40 parts nitric acid (70%) 53 parts water	20 - 30	110 - 120
Nickel Base Alloy	15-5PH, 17-4PH, PH15-7Mo, 17-7PH		10 - 20	72 - 90
	4xx SS	6 parts Turco 4104 10 parts nitric acid (70%) 15 parts phosphoric acid (85%) 69 parts water	15 - 25	110 - 120
Titanium		6 parts Turco 4104 47 parts nitric acid (1) 47 parts water OR 6 parts Turco 4104 58 parts nitric acid (2) 36 parts water	10 - 20 OR 10 - 20	72 - 90 OR 72 - 90

NOTES: (1) Using 42° Be' nitric acid
(2) Using 38° Be' nitric acid

CAUTION

When mixing solutions, always pour acid into water. Do not pour water into acid.

Table 6-1
CLEANING SOLUTIONS FOR PARTS

6.3 Mechanical Cleaning

When mechanical cleaning is required, the following methods may be used:

6.3.1 Procedures

6.3.1.1 Aluminum Alloys

Abrasive pads are preferred since they clean the surface without imbedding oxides (see paragraph 6.3.2.1). Sand paper is acceptable if 220 grit or finer is used (see paragraph 6.3.2.1). A scraper is also recommended if properly used (see paragraph 6.3.2.2). Wire brushing of aluminum is prohibited since the surface oxide is imbedded into the surface.

6.3.1.2 Steels, Nickel Base Alloys, and Titanium

Mechanically clean alloys other than aluminum using sand paper, any grit, abrasive pads, or a wire brush per the instructions in paragraph 6.3.2.1.

6.3.2 Methods

6.3.2.1 Abrasive Cleaning

Abrade all surfaces to be welded, and adjacent surfaces at least 1/2 inch back from the weld joint to prevent the introduction of oxides into the weld which can adversely affect weld quality. Wipe the surface using a cloth or paper wiper wetted with MEK to remove residue.

6.3.2.2 Scraping

Scraping is an effective way to remove oxides from aluminum alloys and one which greatly improves weld quality. Scraping should remove only a thin layer of material with the oxide. DO NOT gouge or nick the surfaces. When using a knife, drag the blade to prevent nicks and gouges. A 3-sided scraper is preferred since it affords better control of the amount of material removed. Wipe the surface using a cloth or paper wiper wetted with MEK to remove residue.

7 QUALIFICATION OF PERSONNEL

GTAW welding personnel shall be qualified and certified in accordance with specification MIL-T-5021D, MIL-STD-1595, or AWS-D17.1:2001 except re-examination shall be every twelve months.

8 WELDING PROCEDURES

8.1 Use of Gas

Helium, Argon, or a mixture of both gasses shall be used to exclude all oxygen and other gasses which might combine with the molten metal to form oxides and other impurities. It also removes oxides from the work surface.

8.2 Cleaning

Metal shall be cleaned prior to welding to ensure removal of foreign matter such as paint, plating or metalizing. Recommended cleaning methods are noted in Section 6.

8.3 Weld Joints

All joints shall be close fitting to avoid excessive weld filling. Gaps on butt joints shall be 0.0 inch minimum to .06 inch maximum. No welds shall be filled with solder, brazing or any other filler.

8.4 Weld Rod Selection

Select the correct weld and/or filler rod material using Table 8-1, 8-2, 8-3, or 8-4 as appropriate.

Base Metal Type	Weld Rod Specification	Filler Rod Type
1100, 3003, 3003 ALCLAD	QQ-R-566	1100
2014, 2024	Not Weldable	----
5052	QQ-R-566	5356
6061	QQ-R-566	4043
7075	Not Weldable	----

Table 8-1
WELDING RODS FOR ALUMINUM ALLOYS

Base Material	Weld Rod Specification	Filler Rod Type
4130, 4140, and 4340 as welded or heat treated	NONE	Linde 71
4130 as welded or heat treated	MIL-R-5632	Type II

Table 8-2
WELDING RODS FOR LOW ALLOY STEELS

Base Material	Weld Rod Specification	Filler Rod Type
201, 202, 301, 302, 304, 305, and 308	MIL-E-19933	308
304L, 308L 321 and 347	MIL-E-19933	308L
303, 303SE	Not Readily Weldable	----
309	MIL-E-19933	309
310	MIL-E-19933	310
316 and 316L	MIL-E-19933	316 and 316L
321, 347	MIL-E-19933	347

Table 8-3
WELDING RODS FOR AUSTENITIC STAINLESS STEELS

Base Material	Weld Rod Specification	Filler Rod Type
17-4PH	NONE	W17-4PH
17-7PH	NONE	W17-7PH

Table 8-4
WELDING RODS FOR PRECIPITATION - HARDENING STAINLESS STEELS

8.5 Welding Procedures

All welding shall be performed in an area ventilated to remove smoke and fumes but also protected from direct drafts which can blow away the gas shielding, adversely affecting the weld quality. Protective screens shall be utilized, as necessary, to protect adjacent work areas from arc light. D.C. Straight Polarity shall be used except for aluminum as noted in paragraph 8.5.2.2.

8.5.1 Steel

Low Alloy Steel and 410SS shall be pre-heated and/or post heated according to Table 8-5.

Base Metal	Preheat Before Tacking or Welding	Postheat (1) Immediately After Welding
4130	Preheat as necessary to prevent crackling and minimize distortion. Recommend 200°F to 400°F for thicknesses above 0.125 inch.	600°F to 800°F. Use only when parts are preheated
4135 & 4140	300°F to 500°F	800°F to 1250°F
4330, 4340, 410SS (2)	400°F to 600°F	1100°F to 1250°F

FOOTNOTES: (1) Post-heat for one hour per inch of maximum weldment thickness.
(2) Weldments shall not be permitted to cool below 200°F prior to start of post heat-treatment.

Table 8-5
LOW ALLOY STEEL PREHEAT AND POSTHEAT REQUIREMENTS

8.5.2 Aluminum

8.5.2.1 Aluminum shall be welded within 24 hours of cleaning. If 24 hours has elapsed, it is permissible to prepare surfaces to be welded by scraping with a weld scraper or a knife, or by abrasion with sand paper or abrasive pads. Do not use wire brushing. Follow with solvent wiping.

8.5.2.2 Welding current shall be D.C. or A.C. Square Wave (with high frequency arc initiation) to provide cathodic cleaning action.

8.5.3 Reactive Metals

8.5.3.1 All reactive metals shall be welded in an inert atmosphere to prevent the formation of oxides which will form at 700°F or higher. For this reason, reactive metal GTAW with no additional shielding is not acceptable.

All reactive metal parts shall be handled using clean white cotton gloves.

8.6 Flux Application

8.6.1 Mix flux per manufacturer's instructions to a consistency that will not run off the joint yet is easily brushed on.

8.6.2 Apply a thin coat of flux to the underside of the weld joint.

8.6.3 Use normal welding techniques with the exception that a partial penetration pass may be used as desired to seal the joint prior to flux application.

8.7 Flux Removal

8.7.1 Since fluxes are acid based, flux should be removed from the weld area as soon as possible and must be removed within 24 hours of welding.

8.7.2 Remove all flux by washing weldment in warm water and brushing with a non-metallic brush.

8.7.3 Air dry after removal, maximum air temperature is 190°F.

9 QUALITY CONTROL

9.1 Verify that all personnel performing Gas Tungsten Arc Welding are qualified per Section 7.

9.2 Verify that each welder posses current certification for the weld joint (material, position, joint design) being welded.

9.3 Verify that proper electrodes, cups, collets, and polarity are being used for welding.

9.4 Verify that the proper filler metal is being used.

9.5 Verify that proper shielding is being used, including back-up shielding.

9.6 Verify proper cleaning of parts prior to welding.

9.7 Verify tack welding as necessary.

9.8 Verify pre/post heating requirements as necessary.

9.9 The weld seam should be smooth and of uniform thickness.

9.10 The weld metal should taper off smoothly into the base metal.

9.11 No oxide should be formed on the base metal at a distance of more than one half inch from the weld.

9.12 The weld should be free of blow holes, porosity or projecting globules.

9.13 The base metal should show no signs of burning, pitting, cracking, or distortion.

9.14 Penetration should be sufficient to ensure fusion of base metal and filler rod.

9.15 Welding scale shall be removed by wire brushing or sand blasting, as appropriate.

9.16 Verify proper non-destructive testing has occurred per paragraph 3.2.

10 MAINTENANCE OF QUALITY CONTROL

10.1 Welded parts shall be routed to paint shop or plating shop as applicable. Parts susceptible to rust shall be coated with a light film of oil for temporary preservation. Parts in storage shall be neatly arranged in racks or storage bins in order to prevent damage to the parts painted or plated surfaces.

10.2 Parts transported or shipped shall be adequately packaged utilizing paper excelsior or other suitable packing material to prevent chafing or crushing from normal handling methods.